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23rd October 1956.

Wind recording apparatus for the new Ballistic Range at Shoeburyness.

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G.E.W. Hartley.

(Meteorological Office)

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METEOROLOGICAL RESEARCH COMMITTEE

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Foreword

Item I.3. (b) was placed on the M.R.C. Programme to meet a requirement at Shoeburyness for measurements of head and side components of wind experienced by a shell along a 3,000 ft trajectory. The required accuracy of measurement, for the average wind over the whole 3,000 ft range, was 1 ft per second.

This accuracy requirement could not be met. It was not practicable to site the anemometer heads nearer than 30 ft horizontally from the trajectory, and, moreover, the height of the trajectory varies. Furthermore, only five towers were available to cover the length of the range. Sampling errors were therefore bound to be quite large. It was considered that something could be done to reduce sampling errors by using 10-15 second mean winds at each measuring point rather than 'instantaneous' (about one second mean) winds.

The anemometer

There are five sets of wind recording apparatus. Each set consists of a wind transmitter, mounted on a 30 ft steel tower, and a wind recorder, housed in a hut at the foot of the tower.

A wind transmitter is shown in Fig. 1. A five-bladed windmill is mounted at the rear end of a horizontal shaft, carried in ball bearings inside a horizontal tube. At the front end of the tube is a hemispherical nosed cylindrical housing containing a Type E.2. SYL Magslip, whose spindle is connected to the front end of the windmill shaft by a flexible coupling.

The tube and housing are mounted on a hollow vertical shaft carried in tufnol bushes, with a thrust ball bearing to take the weight. The vertical shaft is continued downwards to connect with the tubular steel direction rod to the direction recorder.

On the horizontal tube just upstream of the windmill is a vertical fin which holds the windmill into wind. The windmill is mounted at the rear of the horizontal tube so that rain will not blow into the horizontal shaft rear ball bearing.

The five wires from the Magslip are brought down through the hollow vertical shaft to slip rings carried in a housing at the foot of the shaft; brushes pressing on the slip rings are connected to a terminal block on the base of the instrument inside the housing. Below the housing is a 2-inch B.S.P. screwed T-piece, the side opening of which gives access to the direction rod coupling sleeve, and the lower opening provides a method of attachment to a 2-inch gas pipe carried on the tower; this pipe is brought down the tower to the hut below, and forms an enclosure for the direction rod as well as a support for the wind transmitter.

At the foot of the direction rod above the recorder is a flexible coupling, and below it a special clutch which enables the direction rod to be disconnected from the recorder, and replaced without losing orientation.

Wind recorder

This is shown in Figs. 2, 3, 4 and 5. It consists of a run-of-wind recorder, a cosine-of-wind direction recorder, and a synchronous motor driven strip chart mechanism with a chart width of 8 inches and chart speed of 6 inches per minute; the chart is marked with cross-lines at 1/10 inch (i.e., 1 second) intervals.

The chart after use is wound on to a receiving spool.

The run-of-wind recorder

The run-of-wind recorder will be seen at the left-hand side of Fig.3 and close-up in Fig.4. It consists of a Type E.2. SYL Magslip which reproduces the movements of the transmitting Magslip and drives, through a 100:1 worm reduction gear, a vertical spindle at the top of which is a heart-shaped cam. There are two diametrically opposite cam followers, connected together by a light tension spring, and both mounted on vertical spindles; one of these vertical spindles has at its upper end a special pen stirrup, in which rests a tubular pen 5 inches long. The purpose of the second cam follower and spring is to hold the pen-carrying cam follower in contact with the cam. Both followers have rollers to reduce friction.

The cam is so shaped that in 1 revolution the pen moves two inches across the chart and back again; and by means of a special pivoted pen stirrup the circular movement of the pen is converted into a linear movement. The pivoted end of the tubular pen dips into an inkwell carried on a bracket above the top of the stirrup spindle (see Fig.4.). The windmill is designed to make 100 r.p.m. per 10 m.p.h. wind speed, so that 1 inch of pen movement across the chart corresponds to 220 ft of wind flowing past the head.

Assuming a 1-minute chart run, 10 m.p.h. (= 880 ft per min.) will be shown by the pen moving across the chart and back again during a chart movement of 6 inches. The trace will not, of course, be a straight line because of changes in wind speed; but the total distance travelled by the pen across the chart from its starting point will give the run of wind.

Wind direction component recorder

This is shown in Figs.3 and 5. The direction rod from the transmitter is connected, through the clutch already described, to a system of sprockets and chain, cranks, slotted connecting rod and a sliding pen carriage. This is arranged to move the direction pen 2 inches across the chart and back for one complete revolution of the wind vane; but, due to the crank mechanism, the pen movement is not linear with direction but is proportional to the cosine of the angle between the wind direction and the line of the range. Thus when the wind is exactly along the range, the pen is at one end of its travel, i.e., 1 inch to, say, right of centre. When the wind is at right angles to the line of the range the pen is at its central position; when the wind is exactly against range, the pen is at the other end of its travel, i.e., 1 inch left of centre.

Suppose that the angle between wind direction and firing direction is 30°, the pen will be 0.866 inches (cos 30° = 0.866) from its central position and on the positive (say right) side of it.

Backlash in the mechanism is reduced by the chain-tensioning jockey pulley which will be seen in Fig.3.

Chart mechanism and pens

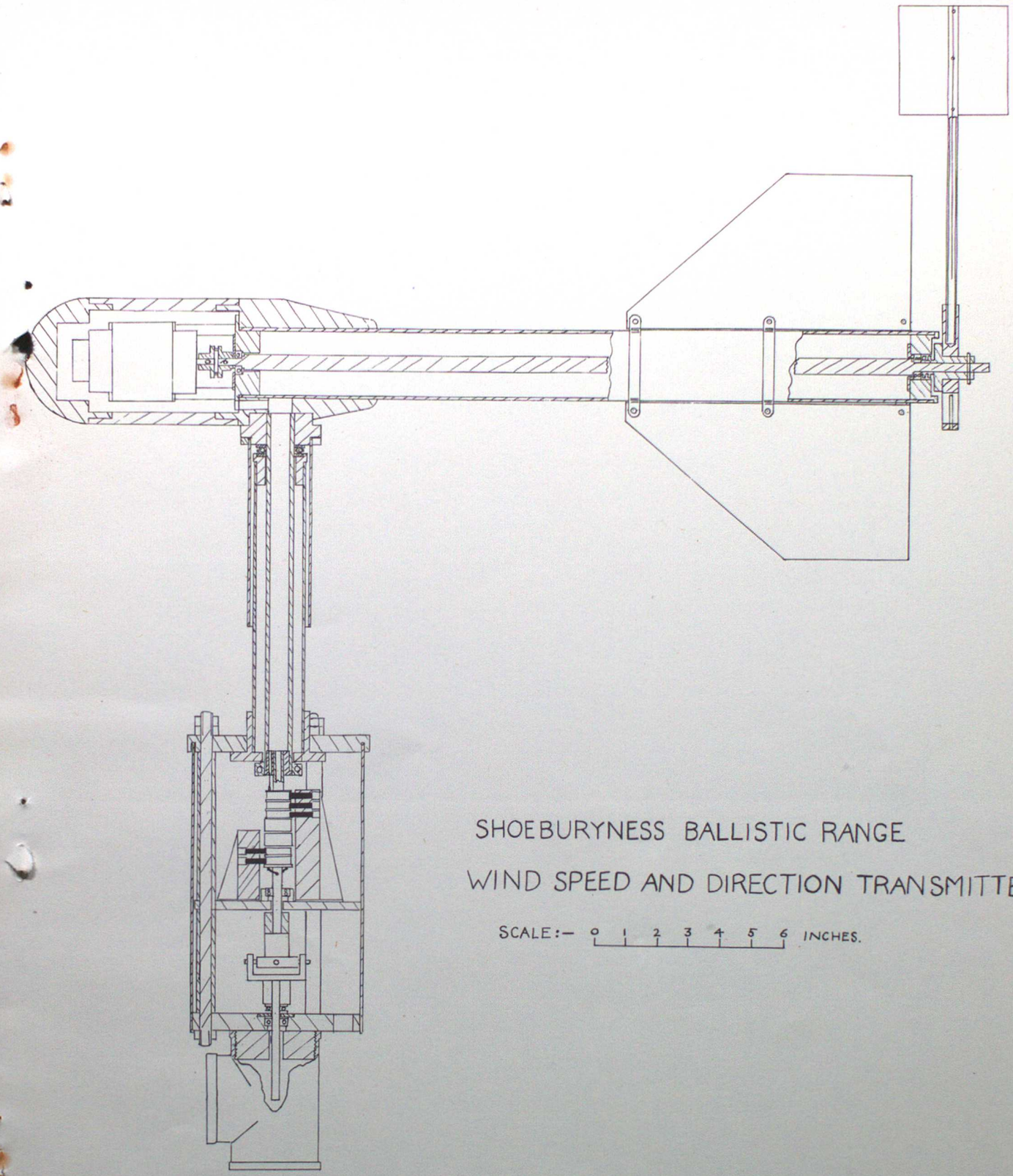
The chart mechanism is a standard double-width chart mechanism made by Everett, Edgcumbe and Co. Ltd., and has a chart speed of 6 inches per minute;

charts are about 60 ft long. The chart is driven by a 230V. A.C. synchronous motor. The pens are made by the same makers, and consist of a length of small-bore tubing bent at right-angles at each end; the writing end carries a screw-on fine-bore writing nozzle; the other end has a cross-bar with knife edges which rest in V-notches in the pen stirrup, and balance weights to adjust the pressure of the pen on the chart; below the cross-bar is an inkwell; the downward-bent pen tube goes through a hole in the centre of the inkwell top cover to dip in the ink. These pens are started by suction. When not in use during intervals between recording they are taken from the instrument and kept in writing order by allowing them to write on a 'storage drum' which consists of a slowly moving chart mounted on a drum driven by a daily clock; this prevents their drying up, and makes it unnecessary to empty and clean them out whenever recording stops. The pens and inkwells are clearly shown in Figs.2 and 4.

Fig.6 shows a chart-reading desk made at Shoeburyness.

Summary

An anemometer and a recording mechanism were developed to meet a special requirement which arose at Shoeburyness. The apparatus has been in use at Shoeburyness for about a year and, apart from minor snags, has worked satisfactorily.



SHOEBURYNESS BALLISTIC RANGE

WIND SPEED AND DIRECTION TRANSMITTER

SCALE:— 0 1 2 3 4 5 6 INCHES.

FIG. 1.

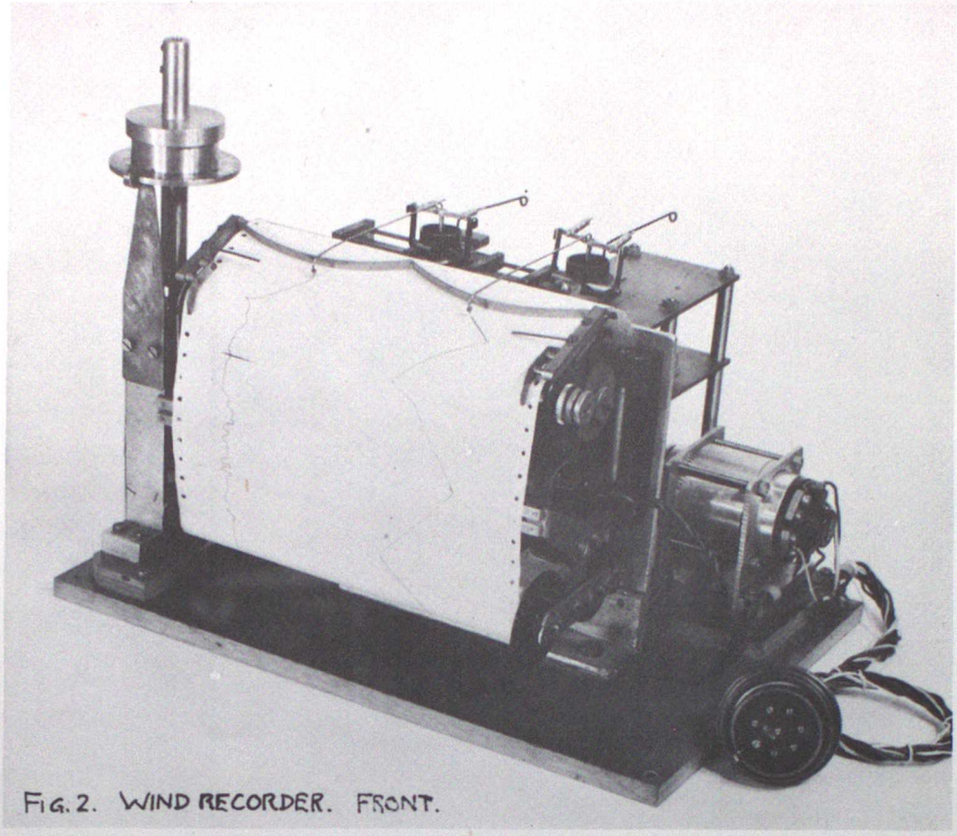


FIG. 2. WIND RECORDER. FRONT.

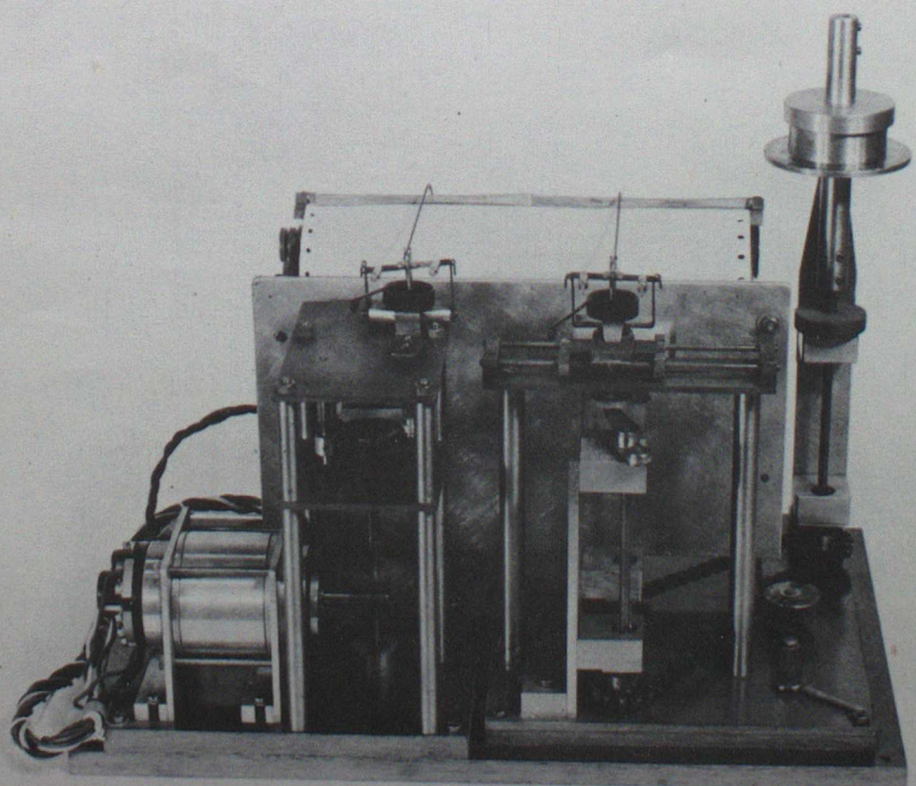


FIG. 3. WIND RECORDER. REAR.

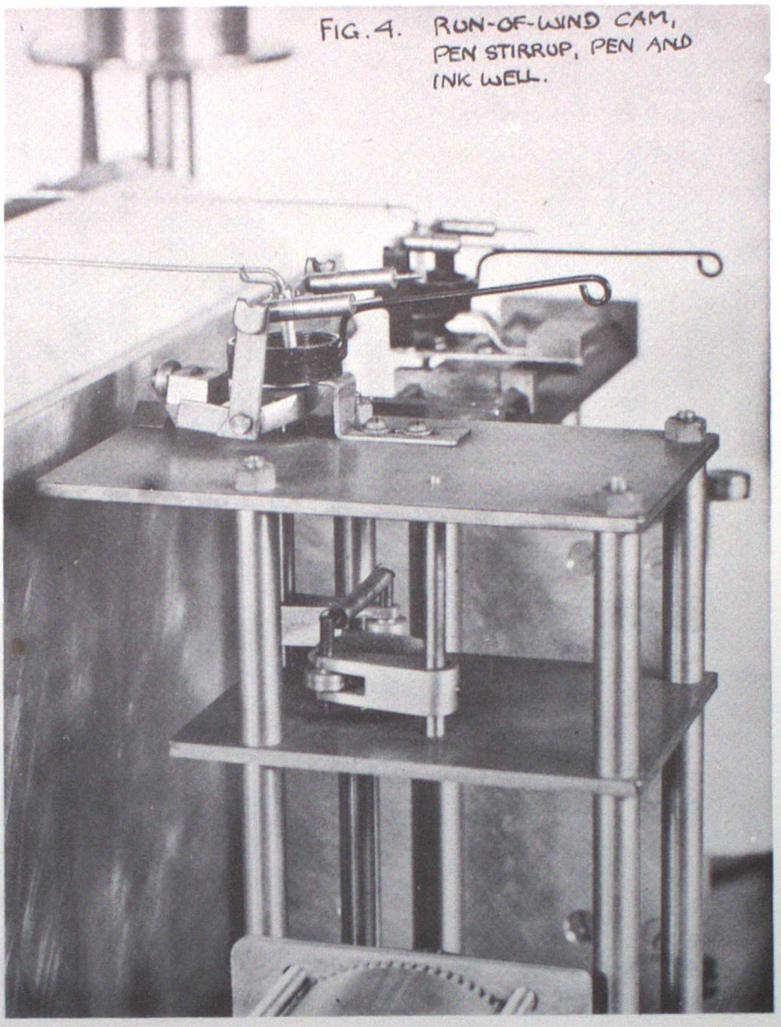


FIG. 4. RUN-OF-WIND CAM, PEN STIRRUP, PEN AND INK WELL.

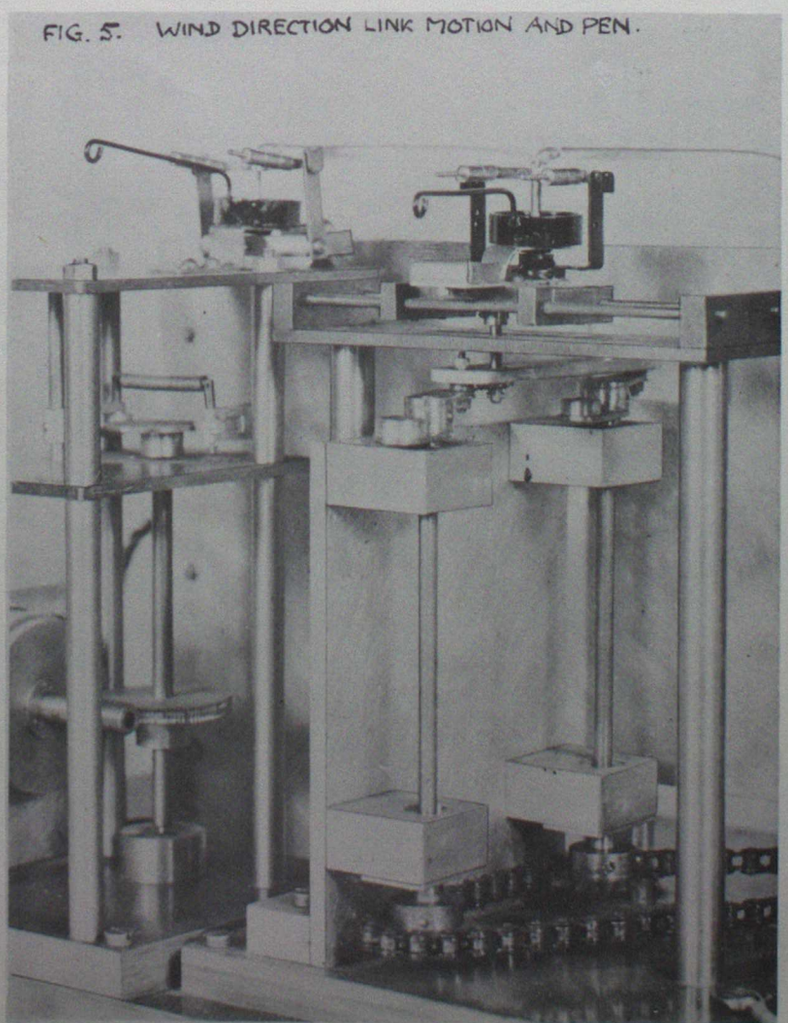


FIG. 5. WIND DIRECTION LINK MOTION AND PEN.

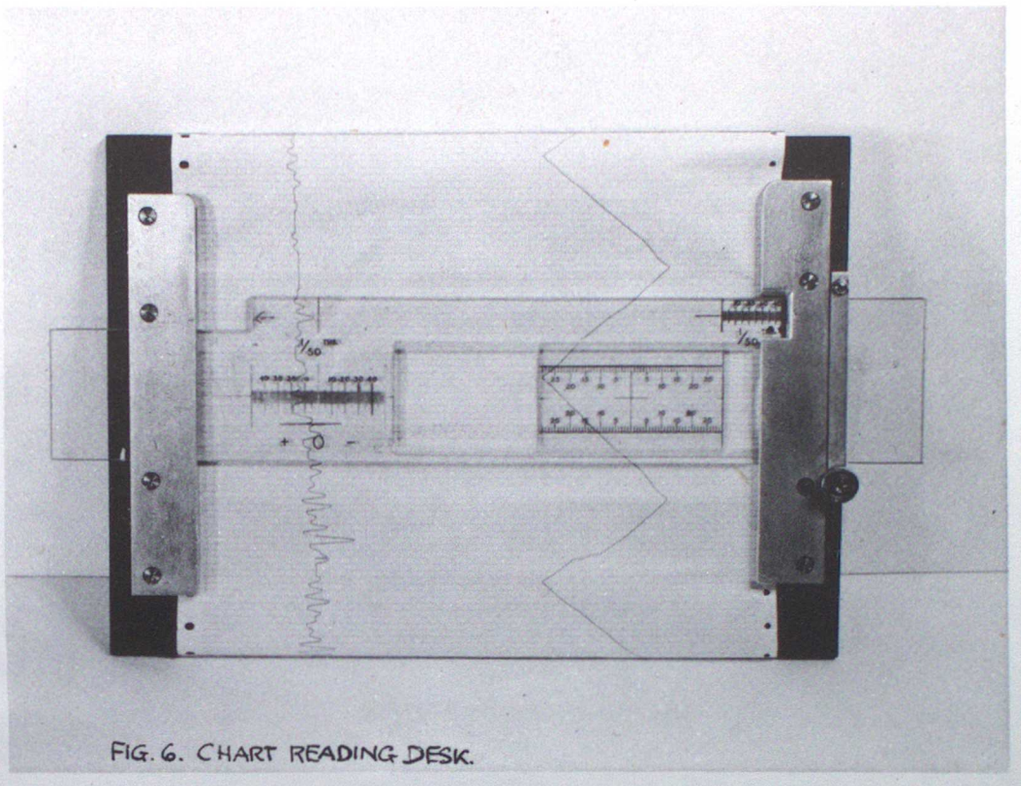


FIG. 6. CHART READING DESK.